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1.

An electric motor under steady load draws 9.7 amperes at 110 volts; it delivers 1.25(hp) of mechanical energy. The temperature of the surroundings is 300 K. What is the total rate of entropy generation in $W \cdot K^{-1}$?

[15 Marks]

2.

Calculate Z and V for sulfur hexafluoride at 75°C and 15 bar by the following equations:

(a) The truncated virial equation with the following experimental values of virial coefficients:

$$B = -194 \text{ cm}^3 \cdot \text{mol}^{-1} \quad C = 15,300 \text{ cm}^6 \cdot \text{mol}^{-2}$$

(b) The truncated virial equation with a value of B from the generalized Pitzer correlation

(c) The Redlich/Kwong equation

(d) The Soave/Redlich/Kwong equation

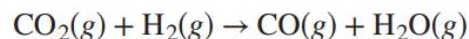
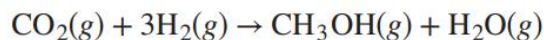
(e) The Peng/Robinson equation

For sulfur hexafluoride, $T_c = 318.7 \text{ K}$, $P_c = 37.6 \text{ bar}$, $V_c = 198 \text{ cm}^3 \cdot \text{mol}^{-1}$, and $\omega = 0.286$.

[25 Marks]

3.

A system formed initially of 2 mol CO_2 , 5 mol H_2 , and 1 mol CO undergoes the reactions:



Develop expressions for the mole fractions of the reacting species as functions of the reaction coordinates for the two reactions.

[10 Marks]

PTO

4. In order to prepare 2 m³ of alcohol-water solution, alcohol of mole fraction 0.4 is required to be mixed with water at 25°C. Determine the volume of alcohol and water needed to prepare the mixture. Given that,

$$\text{Partial molar volume of alcohol} = 38.8 \times 10^{-6} \text{ m}^3/\text{mol}$$

$$\text{Partial molar volume of water} = 17.2 \times 10^{-6} \text{ m}^3/\text{mol}$$

$$\text{Molar volume of alcohol} = 39.21 \times 10^{-6} \text{ m}^3/\text{mol}$$

$$\text{Molar volume of water} = 18 \times 10^{-6} \text{ m}^3/\text{mol} \quad \text{[10 Marks]}$$

5. Assuming the validity of Raoult's law, do the following calculations for the benzene(1)/toluene(2) system:

(a) Given $x_1 = 0.33$ and $T = 100^\circ\text{C}$, find y_1 and P .

(b) Given $y_1 = 0.33$ and $T = 100^\circ\text{C}$, find x_1 and P .

(c) Given $x_1 = 0.33$ and $P = 120 \text{ kPa}$, find y_1 and T .

(d) Given $y_1 = 0.33$ and $P = 120 \text{ kPa}$, find x_1 and T .

[20 Marks]

6. Using the virial equation of state estimate the residual enthalpy and entropy for propane at 60°C and 2.5 bar. [10 Marks]

7. Exhaust steam at 100 kPa and 200°C enters the subsonic diffusion of a jet engine steadily with a velocity of 190 m/s. The inlet area of the diffuser is 2000 cm². The steam leaves the diffuser with velocity of 70 m/s. The pressure difference increase is 200 kPa. The heat losses from the diffuser to the surrounding is estimated to be 100 kW. Determine,
- The mass flow rate of the steam.
 - The temperature of the steam leaving the diffuser.
 - The area of the diffuser outlet.

$$\text{Given that, } V_1 = 2.172 \text{ m}^3/\text{kg} \text{ and } H_1 = 2875.3 \text{ kJ/kg} \quad \text{[15 Marks]}$$

8. Estimate the fugacity of iso-butane at 15 atm and 87 °C using the compressibility factor correlation, given that the second virial coefficient, B is $-4.28 \times 10^{-4} \text{ m}^3/\text{mol}$. [15 Marks]

End